B777 Alerting Issues – Single engine failure/fire

1. Initiating Condition: Engine failure after V1 and prior to V2

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	EICAS caution message "ENG FAIL L or R" or "ENG THRUST L or R"	Actual thrust is less than commanded thrust or thrust decreases below idle speed	Red "ENG FAIL" on PFD attitude displays (only during takeoff roll from 65 knots through v1 minus 6 knots; i.e., not this condition); also master warning lights on forward panel (only during takeoff roll from 65 knots through v1 minus 6 knots; i.e., not this condition); and master caution lights on forward panel during takeoff up to 80 knots (i.e., not this condition). Conceivably the pilots may be expecting these alerts to be associated with an engine failure just after V1, and thus be confused by their absence.	The reasoning for inhibition of alerts at v1-5/80 knots is sound, to avoid a mistaken high speed RTO		Engine recovers or fuel control switch is moved to CUTOFF (during NNP)
	On the EICAS for any abnormal engine indications (EGT, N1, N2, Oil Pressure, Oil Temperature), the associated indication's digital readout, box, and pointer turn amber (caution range) or red (operating limit reached or exceeded). For low oil quantity and high vibration indications, the colors reverse to black text on white background (with "LO" appearing next to the indication for the oil quantity). Secondary engine indications are automatically displayed on lower DU in engine failure condition.					

B777 Alerting Issues – Single engine failure/fire

1. Initiating Condition: Engine failure after V1 and prior to V2 – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	EICAS caution message "AUTOTHROTTLE" (appears later during the ENG FAIL NNP)	Autothrottle arm switch is turned off during NNP				
Aural Alerts	None		Voice annunciation "Engine Fail" (only during takeoff roll from 65 knots through V1 minus 6 knots; i.e., not this condition); and beeper associated with Master Caution light (only during takeoff roll below 80 knots). Conceivably the pilots may be expecting these alerts to be associated with an engine failure just after V1, and thus be confused by their absence	The reasoning for inhibition of alerts at V1-5/80 knots is sound, to avoid a mistaken high speed RTO	Voice alert Inhibited at airspeeds greater than V1 minus 6 knots. Beeper inhibited during takeoff from 80 knots through 400 feet radar altitude or 20 seconds after takeoff.	
Tactile Alerts	None					
Visual Cues	Abnormal EGT, N1, N2, oil temperature, and/or oil pressure gauge indications					
	Nose yawing off runway centerline (minimized by Thrust Asymmetry Compensation (TAC) system)					
Aural Cues	Sounds of engine malfunction may occur		These sounds may be similar to those from engine surge and tire failure			

B777 Alerting Issues – Single engine failure/fire

1. Initiating Condition: Engine failure after V1 and prior to V2 – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Tactile/ Somatic Cues	Lateral g					
	Rudder pressure required to stay on runway (minimized by Thrust Asymmetry Compensation (TAC) system)					
	Reduced longitudinal acceleration					

Expected Pilot Response(s)

- Control the aircraft.
- Execute single engine takeoff/climb profile.
- Identify and execute appropriate non-normal checklist.
- Suppress performing AUTOTHROTTLE procedure; this is specified in the ENG FAIL NNP.
- Perform single engine approach and landing.

Possible sources of confusion with regard to pilot response(s)

- Stress, time pressure, startle.
- Confusion among engine surge, engine failure, tire blowout.
- Partial engine failure may present difficult diagnosis and decision as to whether to shut down.
- After reaching safe altitude and while considering the NNP to execute, possible confusion in deciding between two NNPs: ENG FAIL (which is annunciated on EICAS) and ENG SVR DMG/SEP, which is unannunciated and requires suppression of the ENG FAIL procedure as part of its own NNP).

Issues with regard to multiple concurrent non-normal conditions

- Engine failure presents concurrent electrical, hydraulic, and/or fuel system failures that may require additional action (these should be included in the non-normal procedures and in most cases the EICAS suppresses unnecessary references to the procedures for these secondary failures).
- Uncontained engine failure may present additional multiple alerts and failures.

B777 Alerting Issues – Single engine failure/fire

2. Initiating Condition: Engine failure in cruise flight with autopilot engaged

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Master caution lights on forward panel	Actual thrust is less than commanded thrust or thrust decreases below idle speed				Extinguish by pressing Master Warning/Caution reset
	EICAS caution message "ENG FAIL L or R" or "ENG THRUST L or R"	Actual thrust is less than commanded thrust or thrust decreases below idle speed				Engine recovers or fuel control switch is moved to CUTOFF (during NNP)
	On the EICAS for abnormal engine indications (EGT, N1, N2, Oil Pressure, Oil Temperature), the associated indication's digital readout, box, and pointer turn amber (caution range) or red (operating limit reached or exceeded). For low oil quantity and high vibration indications, the colors reverse to black text on white background (with "LO" appearing next to the indication for the oil quantity). Secondary engine indications are automatically displayed on lower DU in engine failure condition.	Sensed value of respective parameter				
	EICAS caution message "AUTOTHROTTLE" (appears later during the ENG FAIL NNP)	Autothrottle arm switch is turned off during NNP				
Aural Alerts	Beeper associated with Master Caution light	Actual thrust is less than commanded thrust or thrust decreases below idle speed				
Tactile Alerts	None					

B777 Alerting Issues – Single engine failure/fire

2. Initiating Condition: Engine failure in cruise flight with autopilot engaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	Abnormal EGT, N1, N2, oil temperature, and/or oil pressure gauge indications					
	Control wheel deflection (autopilot input)					Control wheel displacement cues are reduced by TAC and further reduced/eliminated after manually trimming the rudder
Aural Cues	Sounds of engine malfunction may occur		These sounds may be similar to those from engine surge			
Tactile/ Somatic Cues	High airframe vibration (possible)					

Expected Pilot Response(s)

- Control the aircraft.
- Identify and execute appropriate non-normal checklist.
- Suppress performing the AUTOTHROTTLE procedure; this is specified in the ENG FAIL NNP.
- Perform single engine approach and landing.

Possible sources of confusion with regard to pilot response(s)

- Stress, time pressure, startle.
- Confusion among engine surge, engine failure.
- Partial engine failure may present difficult diagnosis and decision as to whether to shut down.
- While considering the NNP to execute, possible confusion in deciding between two NNPs: ENG FAIL (which is annunciated on EICAS) and ENG SVR DMG/SEP, which is unannunciated and requires suppression of the ENG FAIL procedure as part of its own NNP).

B777 Alerting Issues – Single engine failure/fire

2. Initiating Condition: Engine failure in cruise flight with autopilot engaged – Cont.

Issues with regard to multiple concurrent non-normal conditions

- Engine failure presents concurrent electrical, hydraulic, and/or fuel system failures that may require additional action (these should be included in the non-normal procedures and in most cases the EICAS suppresses unnecessary references to the procedures for these secondary failures).
- Uncontained engine failure may present additional multiple alerts and failures.

B777 Alerting Issues – Single engine failure/fire

3. Initiating Condition: Engine fire after V1 and prior to V2

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	EICAS warning message "FIRE ENG L or R"	Temperature sensed by engine fire loop	Confusion between fire with and without engine failure		Master warning lights (red, forward glare shield panel) are inhibited during takeoff between V1 and 400 feet radar altitude (however the associated EICAS FIRE message is displayed); Also, burn through of fire detection can suppress valid warnings, leading to false indication that fire has been extinguished. However, this condition is monitored and displayed on EICAS as "DET FIRE ENG L or R," if sensed.	Lower temperature sensed by engine fire loop
	EICAS caution message "OVERHEAT ENG L or R" may precede FIRE ENG L or R warning if overheat threshold is sensed some time prior to fire threshold	Temperature sensed by engine fire loop			Master caution lights (amber, forward glare shield panel), that may precede master warning if overheat is sensed, are Inhibited during takeoff between 80 knots and 400 feet radar altitude (however the associated EICAS OVERHEAT ENG L or R caution message is displayed). Also, caution alert is then suppressed when the sensed temperature reaches fire threshold.	Lower temperature sensed by engine fire loop
	Fire switch light on aisle stand/center console illuminates red	Temperature sensed by engine fire loop			Burn through of fire detection can suppress valid warnings, leading to false indication that fire has been extinguished. This condition is monitored and displayed on EICAS as "DET FIRE ENG L or R," if sensed	Lower temperature sensed by engine fire loop
	Engine fuel control switch (L or R) on center control stand illuminates red	Temperature sensed by engine fire loop			Burn through of fire detection can suppress valid warnings, leading to false indication that fire has been extinguished. This condition is monitored and displayed on EICAS as "DET FIRE ENG L or R," if sensed	Lower temperature sensed by engine fire loop

B777 Alerting Issues – Single engine failure/fire

3. Initiating Condition: Engine fire after V1 and prior to V2 – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	EICAS caution message "AUTOTHROTTLE" (comes on during execution of FIRE ENG NNP)	Autothrottle arm switch is turned off while securing engine as part of the FIRE ENG NNP.				
Aural Alerts	None	Temperature sensed by engine fire loop			Fire Bell alert is inhibited during takeoff between V1 and 400 feet radar altitude (however the associated EICAS FIRE message is displayed). Also, burn through of fire detection can suppress valid warnings, leading to false indication that fire has been extinguished. This condition is monitored and displayed on EICAS as "DET FIRE ENG L or R," if sensed	Bell canceled by the pilots as part of procedure
	None	Temperature sensed by engine fire loop			Beeper associated with engine overheat EICAS caution message that may precede fire bell if overheat sensed, is inhibited during takeoff between 80 knots and 400 feet radar altitude.	Lower temperature sensed by engine fire loop. Also, caution alert suppressed if sensed temperature reaches fire threshold.
Tactile Alerts	None unless engine also fails					
Visual Cues	None unless engine also fails					
Aural Cues	None					
Tactile/ Somatic Cues	None unless engine also fails					

B777 Alerting Issues – Single engine failure/fire

3. Initiating Condition: Engine fire after V1 and prior to V2 – Cont.

Expected Pilot Response(s)

- Control the aircraft.
- Execute V1 engine failure/fire flight profile.
- Execute engine fire procedure (begin procedure above 400 feet, this is earlier than for engine failure procedure).

Possible sources of confusion with regard to pilot response(s)

- Valid fire warning cannot readily be distinguished from false fire warning (see condition 4 below).
- False indication of fire extinguishment, although this is helped by the continual monitoring of the fire detection system's status by EICAS.

How does pilot know condition is resolved/recovered?

- Fire warning indication that fire is extinguished.

Issues with regard to multiple concurrent non-normal conditions

- Engine fire will devolve to an engine failure, either as a direct result of and simultaneous with the fire onset or as part of the engine fire procedure.
- Engine fire presents concurrent electrical, hydraulic, and/or fuel system failures that may require additional action.
- Engine fire may present cascading emergency (e.g., hydraulic failures, smoke in cabin, etc.)
- Uncontrollable fire may present additional, cascading conditions (e.g., structural failure, fuel loss, need to expedite landing, or even land off-airport).

B777 Alerting Issues – Single engine failure/fire

4. Initiating Condition: False fire warning from engine bleed leak during takeoff after V1 and before V2

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	EICAS warning message "FIRE ENG L or R"	Temperature sensed by engine fire loop	Warning is false, there is no fire. There are no salient cues to the fact that there is no fire; absence of engine failure is not, in itself, diagnostic of a false fire warning.	False fire warning can lead to unneeded RTO, engine shutdown, etc.	Master warning lights (red, forward glare shield panel) are inhibited during takeoff between V1 and 400 feet radar altitude (however the associated EICAS FIRE message is displayed); Also, burn through of fire detection can suppress valid warnings, leading to false indication that fire has been extinguished. However, this condition is monitored and displayed on EICAS as "DET FIRE ENG L or R," if sensed.	
	EICAS caution message "OVERHEAT ENG L or R" may precede FIRE ENG L or R warning if overheat threshold is sensed some time prior to fire threshold	Temperature sensed by engine fire loop	Warning is false, there is no fire. There are no salient cues to the fact that there is no fire; absence of engine failure is not, in itself, diagnostic of a false fire warning.	False fire warning can lead to unneeded RTO, engine shutdown, etc.	Master caution lights (amber, forward glare shield panel), that may precede master warning if overheat is sensed,	

B777 Alerting Issues – Single engine failure/fire

4. Initiating Condition: False fire warning from engine bleed leak during takeoff after V1 and before V2

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
					are Inhibited during takeoff between 80 knots and 400 feet radar altitude (however the associated EICAS OVERHEAT ENG L or R caution message is displayed). Also, caution alert is then suppressed when the sensed temperature reaches fire threshold.	
	Fire switch light on aisle stand/center console illuminates red	Temperature sensed by engine fire loop	Warning is false, there is no fire. There are no salient cues to the fact that there is no fire; absence of engine failure is not, in itself, diagnostic of a false fire warning.	False fire warning can lead to unneeded RTO, engine shutdown, etc.	Burn through of fire detection can suppress valid warnings, leading to false indication that fire has been extinguished. This condition is monitored and displayed on EICAS as "DET FIRE ENG L or R," if sensed	
	Engine fuel control switch (L or R) on center control stand illuminates red	Temperature sensed by engine fire loop	Warning is false, there is no fire. There are no salient cues to the fact that there is no fire; absence of engine failure is not,	False fire warning can lead to unneeded RTO, engine shutdown, etc.	Burn through of fire detection can suppress valid warnings, leading	

B777 Alerting Issues – Single engine failure/fire

4. Initiating Condition: False fire warning from engine bleed leak during takeoff after V1 and before V2

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
			in itself, diagnostic of a false fire warning.		to false indication that fire has been extinguished. This condition is monitored and displayed on EICAS as "DET FIRE ENG L or R," if sensed	
	EICAS caution message "AUTOTHROTTLE" (comes on during execution of FIRE ENG NNP)	Autothrottle arm switch is turned off while securing engine as part of the FIRE ENG NNP.				
Aural Alerts	None				Fire Bell alert is inhibited during takeoff between V1 and 400 feet radar altitude (however the associated EICAS FIRE message is displayed). Also, burn through of fire detection can suppress valid warnings, leading to false indication that fire has been extinguished. This condition is monitored and	

B777 Alerting Issues – Single engine failure/fire

4. Initiating Condition: False fire warning from engine bleed leak during takeoff after V1 and before V2

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
					displayed on EICAS as "DET FIRE ENG L or R," if sensed	

B777 Alerting Issues – Single engine failure/fire

4. Initiating Condition: False fire warning from engine bleed leak during takeoff after V1 and before V2 – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Tactile Alerts	None					
Visual Cues	None					
Aural Cues	None					
Tactile/Somatic Cues	None					

Expected Pilot Response(s)

- Control the aircraft.
- Execute V1 engine failure/fire flight profile.
- In the absence of information that the fire warning is false, execute engine fire procedure (begin procedure above 400 feet, this is earlier than for engine failure procedure).
- Suppress performing the AUTOTHROTTLE procedure; this is specified by the FIRE ENG procedure.
- Perform single engine approach/landing procedures.
- If fire indication continues despite attempts to extinguish, expedite landing.

Possible sources of confusion with regard to pilot response(s)

- False fire warning cannot readily be distinguished from valid fire warning (see condition 3 above).

Issues with regard to multiple concurrent non-normal conditions

- False indication of engine fire will likely devolve to an engine failure as part of the engine fire procedure.
- If false indication of fire continues after engine fire NNPs are performed, pilot concerns about inextinguishable fire may prompt risky alternative actions (e.g., rushing, off-airport landing, etc.).